

Name: \_\_\_\_\_

Date: \_\_\_\_\_

## Student Exploration: Human Evolution - Skull Analysis

**Vocabulary:** bipedal, canine, cranial capacity, cranium, evolve, foramen magnum, hominid, hominin, index, maxilla, orbit, palate, skull

**Prior Knowledge Questions** (Do these BEFORE using the Gizmo.)

1. Label one of the **skulls** below as human and the other as a chimpanzee skull.



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2. What features did you use to identify which skull was human and which was chimpanzee?

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### Gizmo Warm-up

In 1924, a fossilized skull that looked very similar to a chimp skull was discovered. But the skull most definitely did not belong to a chimp. The location of the **foramen magnum**—a hole in the skull where the spinal cord exits—indicated that the individual was **bipedal**, or walked on two legs. This fossil was some of the earliest evidence of human evolution.

Using the *Human Evolution – Skull Analysis* Gizmo™, you will discover some of the ways that skulls can be used to learn about human evolution. Start by comparing two modern **hominids**: a human and a chimpanzee.



1. Examine the **Front view** of the ***Homo sapiens* (modern human)** skull. Then, use the **Select skull** menu to examine the same view of the ***Pan troglodytes* (chimp)** skull.


How do the skulls compare? \_\_\_\_\_

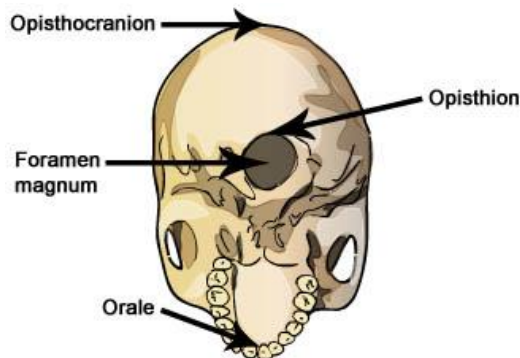
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2. Now, examine the **Bottom view** of the two skulls. How do they compare? \_\_\_\_\_

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| <b>Activity A:</b><br><b>Foramen magnum</b> | <u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>Select the <b><i>Homo sapiens</i></b> (modern human) skull.</li> </ul> |  |
|---|---|---|



**Introduction:** Skulls, even from the same species, can have a wide variety of shapes and sizes. To compare skulls, scientists use measurements of certain features to calculate indexes. An **index** is a ratio of one measurement to another.

An important index for measuring hominid skulls is the *opisthion index*. This index indicates the position of the foramen magnum in the base of the **cranium**. The opisthion index can indicate whether a hominid species was bipedal or not.

**Question: How does the location of the foramen magnum indicate if a species was bipedal?**

1. **Measure:** Select the **Bottom view**. To determine the opisthion index for humans and chimps, follow the steps below and complete the table.
  - Turn on **Click to Measure Lengths**. Measure the distance from the opisthocranium to the opisthion, as shown at top right. Record the opisthocranium-opisthion distance in the table below.
  - Measure from the opisthocranium to the orale, as shown at bottom right. Record the opisthocranium-orale distance in the table.
  - To calculate the opisthion index, divide your first measurement by your second measurement. Multiply this number by 100.



| Species                | Opisthocranium-opisthion distance (cm) | Opisthocranium-orale distance (cm) | Opisthion index |
|------------------------|--|------------------------------------|-----------------|
| <i>Homo sapiens</i>    |  |                                    |                 |
| <i>Pan troglodytes</i> |  |                                    |                 |

2. **Analyze:** The opisthion index is an indicator of where the foramen magnum is situated. The greater the opisthion index, the closer the foramen magnum is to the center of the cranium. This position is usually found in species that stand upright. A low value for the opisthion index occurs when the foramen magnum is situated in the rear of the cranium. This may indicate that the species walked on its knuckles or on four legs.

Using the index values you calculated, what can you conclude about humans and chimps?

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(Activity A continued on next page)

### Activity A (continued from previous page)

3. **Gather data:** Humans, chimpanzees, and the other great apes are hominids. Hominids **evolved** from a common ancestor that lived about 13 million years ago. **Hominins** are hominids that belong to the lineage that led to humans.

Measure the opisthion index of the other hominids available in the Gizmo.

| Species                                      | Opisthocranium-opisthion distance (cm) | Opisthocranium-orale distance (cm) | Opisthion index |
|--|--|------------------------------------|-----------------|
| <i>A. afarensis</i>                          |  |                                    |                 |
| <i>A. africanus</i>                          |  |                                    |                 |
| <i>P. boisei</i>                             |  |                                    |                 |
| <i>H. habilis</i>                            |  |                                    |                 |
| <i>H. erectus</i>                            |  |                                    |                 |
| <i>H. heidelbergensis</i>                    |  |                                    |                 |
| <i>H. sapiens</i><br><i>neanderthalensis</i> |  |                                    |                 |
| <i>H. floresiensis</i>                       |  |                                    |                 |

4. **Analyze:** Hominins are characterized by bipedalism.

A. Based on their opisthion indexes, which of the hominids in the Gizmo are hominins?

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B. Based on opisthion indexes, which hominin skulls are most similar to human skulls?

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4. **Explain:** Why do you think the foramen magnum is positioned near the rear of the cranium for knuckle-walking species and near the center of the cranium for bipedal species?

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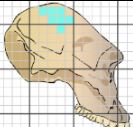
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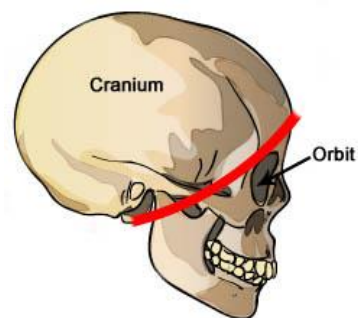


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|---|--|---|
| <b>Activity B:</b><br><br><b>Cranial capacity</b> | <u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>• Select <b>Side view</b>.</li> <li>• Turn off <b>Ruler</b>, and turn on <b>Click to measure area</b>.</li> </ul> |  |
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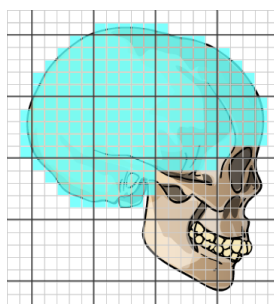
**Introduction:** The brain is housed inside the cranium. The internal volume of the cranium is called the **cranial capacity**. The larger an organism's cranial capacity is, the larger its brain tends to be.

**Question: How does the cranial capacity compare amongst hominids?**

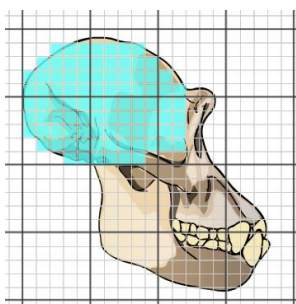
1. **Measure:** To estimate the cranial capacity of each skull in the Gizmo, measure the area of the part of the cranium that houses the brain. This part of the cranium is roughly behind the red line in the diagram at right. You can also use the three skull images below as a guide for measuring the rest of the skulls in the Gizmo.



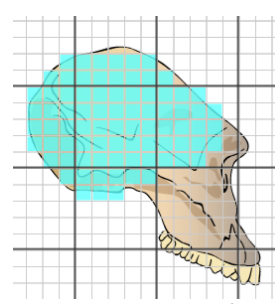
After you measure the area of each cranium, multiply the result by 5. This will give you a very rough estimate of the species' cranial capacity.



*Homo sapiens*



*Pan troglodytes*



*Australopithecus afarensis*

| Species                            | Area of cranium (cm <sup>2</sup> ) | Estimated cranial capacity (cm <sup>3</sup> ) |
|------------------------------------|------------------------------------|---|
| <i>Pan troglodytes</i>             |                                    |   |
| <i>A. afarensis</i>                |                                    |   |
| <i>A. africanus</i>                |                                    |   |
| <i>P. boisei</i>                   |                                    |   |
| <i>H. habilis</i>                  |                                    |   |
| <i>H. erectus</i>                  |                                    |   |
| <i>H. heidelbergensis</i>          |                                    |   |
| <i>H. sapiens neanderthalensis</i> |                                    |   |
| <i>H. floresiensis</i>             |                                    |   |
| <i>H. sapiens</i>                  |                                    |   |

(Activity B continued on next page)

**Activity B (continued from previous page)**

2. Analyze: Examine the estimated cranial capacities you calculated.

A. Which species probably had the largest cranial capacities?

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B. What do you think cranial capacity is a good indicator of? \_\_\_\_\_

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C. Did any hominids have a larger cranial capacity than humans? If so, which species?

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3. Compare: Turn off the **Area** tool. Using the **Front view**, compare the size and shape of the forehead of a chimpanzee and the forehead of a modern human. How are they different?

A. How are they different? \_\_\_\_\_

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B. Why do you think humans have such large foreheads in comparison to chimps?

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5. Draw conclusions: Compare the data you collected in activity A with the data you collected in this activity. Which evolved first in hominins: bipedalism or large brains? Explain.


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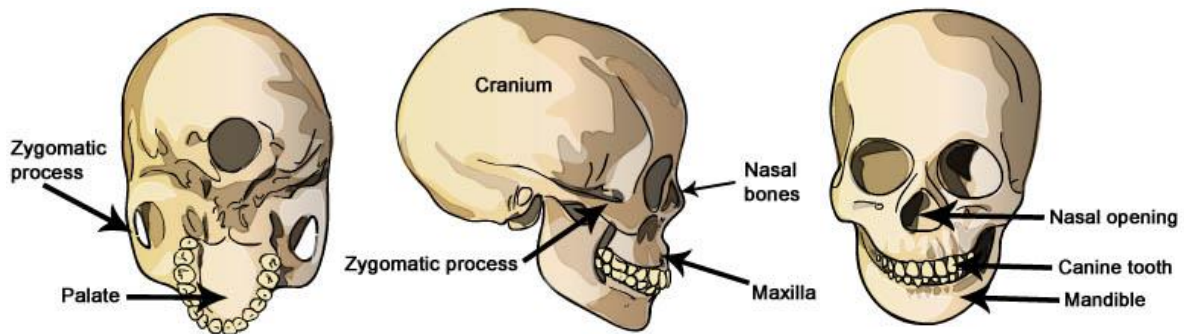
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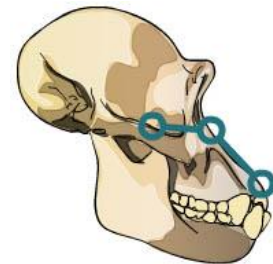
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| <b>Activity C:</b><br><br><b>Maxilla and mandible</b> | <b>Get the Gizmo ready:</b> <ul style="list-style-type: none"> <li>• Select <b>Side view</b>.</li> <li>• Turn on <b>Click to measure angles</b>.</li> </ul> |  |
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**Introduction:** Teeth and the bones around the mouth give a great deal of information about both a species' diet and how it eats. Take a look at the skull features below.



**Question: How do the mouths of hominids compare?**

1. **Measure:** As shown at right, place one of the protractor's circles on the top of the zygomatic process. Place the vertex of the protractor at the top of the nasal opening (Hint: You may have to look at the **Front view** in order to see where the top of the nasal opening is in relation to the **orbit**). Place the other circle on the edge of the **maxilla**. The resulting angle is the *maxillary angle*. Complete the table. (Note: You will not be able to do this measurement on incomplete skulls.)



| Species                           | Maxillary angle | Species                              | Maxillary angle |
|-----------------------------------|-----------------|--------------------------------------|-----------------|
| <i>Pan troglodytes</i>            |                 | <i>Homo erectus</i>                  |                 |
| <i>Australopithecus afarensis</i> |                 | <i>Homo heidelbergensis</i>          | —               |
| <i>Australopithecus africanus</i> |                 | <i>Homo sapiens neanderthalensis</i> | —               |
| <i>Paranthropus boisei</i>        |                 | <i>Homo floresiensis</i>             |                 |
| <i>Homo habilis</i>               | —               | <i>Homo sapiens</i>                  |                 |

2. **Observe:** Select the **Bottom view** and look at the size and shape of each species' **palate**. How does the maxillary angle and palate shape relate to the size of each species' mouth?

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**(Activity C continued on next page)**

**Activity C (continued from previous page)**

3. Compare: Compare the human's and chimp's teeth.

A. How many teeth are found in each species' maxilla?

*Pan troglodytes*: \_\_\_\_\_ *Homo sapiens*: \_\_\_\_\_

B. How do the size and shape of human **canines** compare with chimp canines?

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4. Form hypothesis: Chimps and humans eat similar foods. What do you think could explain the differences between the maxillary angle, teeth, and palate of these two species?

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5. Infer: What is the relationship between the evolution of bipedalism, the increase in cranial capacity, and the decrease in tooth and mouth size of hominins? (Hint: As cranial capacity increased, the use of sophisticated stone tools became more common.)

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6. Summarize: On a separate sheet of paper, record the age of each fossil. Then, look over all the data you collected. Summarize how hominins changed as they evolved. \_\_\_\_\_

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7. Evaluate: Of the fossils presented in this Gizmo, *Homo floresiensis* is the youngest. In what ways does this species NOT follow the pattern of human evolution you described above?

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